the more convenient, as the first decimal place is always sufficient. But in Europe and in North America, where the greater number of meteorological observatories is situated, the temperature falls every year below the freezing point of water. In some localities it passes quickly through this point and remains constantly below, often far below it, returning again in the spring and passing as quickly through it again in the beginning of summer, to remain constantly above it until it drops away again in the fall of the year In such places, where, however, the population affected is limited, the use of Celsius' scale is not open to very much objection. With the exception of a few days in the fall, and again in the spring of the year, the temperatures are either continuously positive or continuously negative; and during one-half of the year the observer reads his thermometer upwards, while during the other half of the year he reads it downwards. When he has got well into the one or the other half of the year, he will make no more errors than those that he is personally liable to under circumstances of no difficulty. But at and near the two dates when the temperature is falling or rising through that of melting ice the case is very different. If the rise or fall is rapid, his task is comparatively easy, and, after a few unavoidable mistakes, he has succeeded in inverting his habit of reading. But, in those parts of Europe and North America which carry nearly the whole of the population, the temperature in winter is frequently oscillating from one side to the other of the melting point of ice. If the observer is compelled to use a thermometer which he must read upwards when the temperature is on one side of that point, and downwards when it is on the other side, and if he may be called on to perform this fatiguing functional inversion several times in one day, it is certain that he will suffer from exhaustion, and that the observations will be affected with error.

Were there no other thermometric scale available but that of Celsius, we should simply have to put up with it, and endure the inconvenience of it; but, when we have another scale, one devised primarily for meteorological observations in the North of Europe, by a philosopher who constructed it with a single eye to its fitness for what it was to be called upon to measure, and when, in addition, this scale is still exclusively used in a large proportion of the meteorological observatories of the world, it seems almost incredible that amongst reasonable people, be they scientific or non-scientific, there should be a powerful agitation to abolish the scale which was devised for its work, which excludes error in so far as it can be excluded, and to replace it by one which, besides other defects, introduces, in the nature of things and of men, *avoidable* errors, the elimination of which is the first preliminary of the scientific treatment of all observations in nature.

Every meteorologist in northern countries who makes use of the data which he collects knows that when his temperatures are expressed in Fahrenheit's degrees, he can discuss them at much less expense both of labour and of money for computing than when they are expressed in Celsius' degrees; yet such is the apprehension of even scientific men when brought face to face with the risk of being ruled "out of fashion," that meteorologists who use Fahrenheit's scale, though they fortunately do not give up its use, seem to be disabled from defending it.

What is this stupefying fashion, and can it not be made our friend?

Fahrenheit lived and died before the decimal cult or the worship of the number ten and its multiples came into vogue; but, whether in obedience to the prophetic instinct of great minds or not, it almost seems as if he had foreseen and was concerned to provide for the weaknesses of those that were to come after him. The reformers of weights and measures during the French revolution rejected every practical consideration, and chose the new fundamental unit, the metre, of the length that it is, because they believed it to be an exact decimal fraction one ten-millionth of the length of the meridian from the pole to the equator. Is it an accident that mercury, which was first used by Fahrenheit for filling thermometers, expands by almost exactly one ten-thousandth of its volume for one Fahrenheit's degree?

Again, how did Fahrenheit devise and develop his thermometric scale? A native of Danzig and living the first half of his life there, he considered that the greatest winter cold which he had experienced in that rigorous climate might, for all the purposes of human life, be accepted as the greatest cold which required to be taken into account. He found that this temperature could be reproduced by a certain mixture of snow and salt. As a higher limit of temperature which on similar grounds he held to be the highest that was humanly important, he took the temperature of the healthy human body, and he subdivided the interval into twenty-four degrees, of which eight, or one-third of the scale, were to be below the melting point of pure ice, and two-thirds or sixteen were to be above it. Fahrenheit very early adopted the melting temperature of pure ice for fixing a definite point on his thermometer, but he recognised no right in that temperature to be called by one numeral more than by another. The length of his degree was one-sixteenth of the thermometric distance between the temperature of melting ice and that of the human body, and the zero of his scale was eight of these degrees below the temperature of melting ice, and not, as is often thought, the temperature of a mixture of ice and common salt or sal-ammoniac. Fahrenheit, as has been said, was the first to use mercury for filling thermometers; and being a very skilful worker, he was able to make thermometers of considerable sensitiveness, on which his degrees occupied too great a length to be conveniently or accurately subdivided by the eye. To remedy this he divided the length of his degree by four, and the temperature from the greatest cold to the greatest heat which were of importance to human life came to be subdivided into 96 degrees.

Had he lived in the following century he would have been able to point out that on his scale the range of temperature within which human beings find continued existence possible is represented by the interval 0 to 100 degrees, and there can be little doubt that this would have secured its general adoption. Its preferential title to the name Centigrade is indisputable. Perhaps this may be an assistance to its rehabilitation as the thermometer of meteorology. J. Y. BUCHANAN.

Cambridge, August 4.

On the Deduction of Increase-Rates from Physical and other Tables.

THE problem treated by Prof. Everett in your issue of July 20, p. 271, allows a somewhat simpler solution. Take the example given by Prof. Everett. To find the value of $\frac{dp}{d\theta}$ at the temperature 105°, we have only to consider the columns for Δp, $\Delta^3 p$, $\Delta^5 p$, &c. In each of these columns there are two numbers, one just above and one just below the horizontal line, corresponding to the value $\theta = 105°$. In the column for Δp, for instance, these two numbers are 408 and 470, in the column for $\Delta^3 p$ they are 5 and 8 If now m_1, m_3, m_5, &c., are the means of each of these two numbers, so that in this case $m_1 = 439$, $m_3 = 6.5$, we have:

$$\frac{hdp}{d\theta} = m_1 - \frac{m_3}{2.3} + \frac{m_5}{2.3.4.5}2^2 - \frac{m_7}{2.3.4.5.6.7}2^2 3^2 + \dots$$

If p be capable of being expressed in the form $A + B\theta + C\theta^2$ only the first term m_1 is required; if

$$p = A + B\theta + C\theta^2 + D\theta^3 + E\theta^4$$

only the first two terms $m_1 - \frac{m_3}{2.3}$ are required, and so forth. In these cases the solution is exact, whereas in general the method gives only approximations closer and closer the more terms are added.

The difference between my solution of the problem and Prof. Everett's is only formal. It may readily be seen that in Prof. Everett's notation

$$2m_1 = d_1 + u_1,\ 2m_3 = d_2 - u_2,\ 2m_5 = (d_3 + u_3) - (d_2 - u_2),$$

which makes his equations special cases of my expression for $\frac{hdp}{d\theta}$. The proof of my expression may be given by the calculus of finite differences. For simplicity let us write $x = \theta - 105°$, and let us develop the function p in the form:

$$p = a_0 + a_1 x + \frac{a_2}{2}x(x-h) + \frac{a_3}{2.3}(x+h)x(x-h) + \dots$$

General terms:

$$\frac{a_{2n}}{2.3.4\ \dots\ 2n}(x + (n-1)h)\ \dots\ x\ \dots\ (x - nh).$$

$$+ \frac{a_{2n} + 1}{2.3.4\ \dots\ 2n+1}(x + nh)\ \dots\ x\ \dots\ (x - nh)$$

By the calculus of finite differences we obtain :

$$\frac{\Delta p}{h}=\frac{p(x+h)-p(x)}{h}=a_1+a_2x+\frac{a_3}{2}(x+h)x+\frac{a_4}{2.3}(x+h)x(x-h)+\ldots$$

and

$$\frac{\Delta^2 p}{h^2}=a_2+a_3(x+h)+\frac{a_4}{2}(x+h)x+\frac{a_5}{2.3}(x+2h)(x+h)x+\ .\ .\ .$$

Therefore :

$$ha_1=\Delta p \text{ for } x=0 \text{ and } h^2a_2=\Delta^2 p \text{ for } x=-h$$

By proceeding in the same way we find $h^{2v}a_{2v}=\Delta^{2v}p$ for $x=-vh$ and $h^{2v+1}a_{2v+1}=\Delta^{2v+1}p$ for $x=-vh$.

The value of $\Delta^{2v}p$ for $x=-vh$ is the number in the column for $\Delta^{2v}p$, which stands in the horizontal line corresponding to the stated value of θ (105 in our case), while the value of $\Delta^{2v+1}p$ for $x=-vh$ is the number in the next column just below this line. The mean of this number and the one above it we have before denoted by m_{2v+1}; we now add the notation m_{2v} for the value of $\Delta^{2v}p$ for $x=-vh$. As m_{2v+2} is the difference of the two numbers, whose mean is m_{2v+1}, we can write $m_{2v+1}+\frac{1}{2}m_{2v+2}$ instead of the value of $\Delta^{2v+1}p$ for $x=-vh$.

We have therefore :

$$a_{2v}=m_{2v}h^{-2v}$$

and

$$a_{2v+1}=(m_{2v+1}+\tfrac{1}{2}m_{2v+2})h^{-2v}.$$

Substituting these values in the expression for p we have :

$$p=a_0+(m_1+\tfrac{1}{2}m_2)\frac{x}{h}+\frac{m_2}{2}\frac{x(x-h)}{h^2}$$

$$+\frac{1}{2.3}(m_3+\tfrac{1}{2}m_4)\frac{(x+h)x(x-h)}{h^3}+\ .\ .\ .$$

General terms :

$$\frac{1}{2.3\ .\ .\ .\ 2v+1}(m_{2v+1}+\tfrac{1}{2}m_{2v+2})(x+vh)\ \ldots\ x\ \ldots\ (x-vh)h^{2v-1}$$

$$+\frac{1}{2.3\ .\ .\ .\ 2v+2}m_{2v+2}(x+vh)\ .\ .\ .\ x\ .\ .\ .\ (x-vh)$$

$$(x-(v+1))h^{-2v-2}.$$

To find the value of $\frac{dp}{d\theta}$ we now need only differentiate according to x and make x equal zero.

Thus we obtain :

$$h\frac{dp}{d\theta}=(m_1+\tfrac{1}{2}m_2)-\frac{m_2}{2}-\frac{1}{2.3}(m_3+\tfrac{1}{2}m_4)+\frac{1}{2.3}\frac{m_4}{2}+\ .\ .\ .$$

General terms :

$$\frac{(-1)^v}{2.3\ .\ .\ .\ 2v+1}(m_{2v+1}+\tfrac{1}{2}m_{2v+2})2^2\ .\ 3^2\ \ .\ .\ .\ v^2$$

$$+\frac{(-1)^{v+1}}{2.3\ .\ .\ \ 2v+2}m_{2v+2}\ .\ (v+1)\ .\ 2^2\ .\ 3^2\ \ .\ .\ .\ v^2;$$

or by contracting two consecutive terms :

$$h\frac{dp}{d\theta}=m_1-\frac{1}{2\ .\ 3}m_3+\frac{1}{2\ .\ 3\ .\ 4\ .\ 5}m_5\ .\ 2^2-\ .\ .\ .$$

The second differential coefficient is found in a similar way. It is only necessary to observe that the second differential coefficient of $(x+vh)\ .\ .\ .\ x\ .\ .\ .\ (x-vh)$ vanishes for $x=0$ and that of $(x+vh)\ .\ .\ .\ x\ .\ .\ .\ (x-(v+1)h)$ is equal to $2\ .\ (-1)^v\ .\ 2^2\ .\ 3^2\ .\ .\ .\ v^2h^{-2v}$. Therefore we obtain

$$h^2\frac{d^2p}{d\theta^2}=m_2-\frac{2}{2\ .\ 3\ .\ 4}m_4+\frac{2}{2\ .\ 3\ .\ 4\ .\ 5\ .\ 6}\ .\ 2^2\ .\ m_6-\ .\ .\ .$$

General term :

$$\pm\frac{2}{2\ .\ 3\ .\ 4\ .\ .\ .\ 2v+2}2^2\ .\ 3^2\ \ .\ .\ .\ v^2\ .\ m_{2v+2}.$$

Hannover, Technische Hochschule. C. RUNGE.

PROF. RUNGE'S proof is longer and more difficult than mine; but his result is in simpler shape, and possesses the great merit of giving the successive approximations as the terms of a regular series. J. D. EVERETT.

22 Earl's Court Square, July 28.

The So-called "Thunder"-storm.—Prevalence of Anticyclones.

IT must have occurred to others besides myself how very absurd it is to designate a meteorological phenomenon by the least important of its characteristics, viz. the noise it makes. We never speak of a hail-storm as a "rattle"-storm, or a shower of rain as a "patter"-storm; why then should we call an electrical disturbance a "thunder"-storm? Thunder, though no doubt terrifying to savages and children and old ladies (one or two of whom have, I believe, been killed by the fright of it), and though of some interest as an acoustic phenomenon, is absolutely the most trivial of the accompaniments of an electrical discharge.

It would seem hopeless to eradicate the childish term entirely from popular language, but surely in the scientific reports and forecasts issued by the Meteorological Office, and in scientific literature generally, the term "electric storm" (or disturbance) might replace "thunderstorm."

With regard to the late prevalence and persistence of anticyclonic conditions over the centre and south of our islands, I wish to suggest that it may be connected with the unusual extension southwards of the Polar ice-pack this summer. I saw it stated about a month ago that even Spitsbergen was then surrounded by ice, most of the fiords being quite inaccessible. When I was there in July 1896 we could only just see the blink of the pack in the north horizon.

Now, it is an ascertained and easily intelligible fact that areas of cold (water or ice) on the earth's surface have a tendency to cause the formation of areas of high pressure or dense air in the atmosphere above them. The result would be, not only a prevalence of anticyclones in high latitudes over the North Atlantic, but also the persistent extension of the northern edge of the great "Atlantic anticyclone" over the south and centre of England (attracted, as it were, by the high pressure in the north); so that cyclones which usually strike the south-west of Ireland or the coast of Cornwall have been "fended off" to the north of Scotland, with the result of heat and drought over England.

I only put this forward as a suggestion, and I should be glad if any of your Icelandic or Norwegian readers would supply details of the position of the Polar ice-pack, temperature of the sea in the North Atlantic, &c., for I have learnt to mistrust all statements appearing in those interesting, and often sensational, works of fiction—the daily papers. METEOR.

August 12.

Scoring at Rifle Matches.

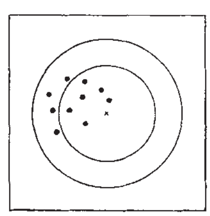
WHILE the Bisley meeting is still fresh in the memory of those interested in rifle shooting, it seems worth while to call attention to the rather unsatisfactory nature of the method of scoring now in general use.

What brings the matter into special prominence is the large number of "best possibles" always made in recent years.

With a satisfactory system of scoring such a phrase ought only to apply when every shot passes through the same hole in the centre of the bull's-eye.

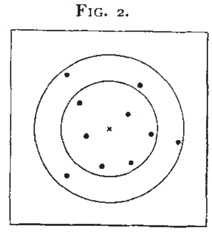
The present practice, however, gives the same number of marks to shooting of widely differing merit, and this must always be the case as long as the result is made to depend on the distance of each shot from the centre of the target, irrespective of the distance of the shots from one another (see Figs. 1 and 2).

FIG. 1.



Ordinary score 46.
By moment of inertia 24·5.

FIG. 2.



Ordinary score 46.
By moment of inertia 18.

The merit of any series of shots really depends on two elements, namely, the distance of the average direction of the whole series from the centre of the target and the compactness with which the individual shots are grouped about that direction.

The importance to be assigned to each of these elements may vary with the object for which the shooting is undertaken, but a knowledge of both is essential in estimating its quality.

If the object be to get all the shot as near the centre of the target as may be, the same importance should be attached to close grouping as to the mean direction, as will be shown further on.